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INTEGRATED BATTLEFIELD EFFECTS RESEARCH FOR THE NATIONAL TRAINING CENTER

Science Applications International Corporation
P. O. Box 2351
La Jolla, CA 92038-2351

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Research performed to evaluate and develop enhancements for integrated battlefield training at the U.S. Army National Training Center is described. These enhancements had been identified and concepts developed for their application in earlier phases of this research. The report consists of the basic volume summarizing the research tasks, approach, results, conclusions, and recommendations; plus twelve appendices which provide details on the nine major tasks into which the research was divided. Research performed and the associated appendices are as follows:

Development of nuclear and chemical environmental and effects software:

- Analysis of nuclear algorithms — Appendix A
- Requirements specification for nuclear and chemical model algorithms at the NTC — Appendix B
- Chemical model algorithm description — Appendix C

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19. ABSTRACT (Continued)

Demonstration of the system for combining live and notional battalions for training higher level staffs in integrated battlefield (IB) command and control:

Functional requirements analysis for IB command and control simulation	Appendix D
Report on the demonstration	Appendix E

Analysis and design of field simulators for nuclear and chemical warfare:

Technical and operational impacts of field simulators	Appendix F
Capability of off-the-shelf paging system to communicate at Ft. Irwin	Appendix G
Designs of field simulators	Appendix H

Adaptation of nuclear and chemical software to other Army training models:

Feasibility of transferring ARTBASS Code from Perkin-Elmer to VAX	Appendix I
Division/Corps training simulation functional analysis	Appendix J
ARTBASS conversion to VAX	Appendix K
Requirements specification for adding nuclear and chemical models to ARTBASS	Appendix L

This research provided the following products:

Software which models nuclear and chemical environment and effects with appropriate fidelity and timing for training and which is ready for installation on NTC computers.

A demonstrated capability for combining actions of real battalions with computer simulated notional battalions for training brigade/division commanders and staffs.

An analysis of the impacts of using field simulators at the NTC for nuclear and chemical warfare training, and the designs of the selected simulators (i.e., common control system, radiacmeters, dosimeters, chemical detectors).

Analysis of the application of nuclear and chemical models to other Army battalion training models; conversion of the ARTBASS model to operate on the VAX 11/780; incorporation of the nuclear and chemical models into ARTBASS; and demonstration of the nuclear and chemical models using ARTBASS.

PREFACE

This report documents the third phase of a research program to enhance Integrated Battlefield (IB) training at the U.S. Army National Training Center (NTC) at Fort Irwin, California. In this context, IB refers to nuclear and chemical warfare, and command and control actions on the integrated battlefield.

The research also includes support in adaptng the nuclear and chemical algorithms which have been developed, for use in common Army battle simulation training models.

Background, description of tasks, results, conclusions, and recommendations for the nine major tasks in this phase are documented in a single volume. Details of these tasks are provided in twelve appendices which are bound separately, and provided with the main volume. Titles of appendices are found in Table 1 on page 7.

CONVERSION FACTORS FOR U.S. CUSTOMARY TO METRIC (SI) UNITS OF MEASUREMENT

To Convert From	To	Multiply By
angstrom	meters (m)	1.000 000 x E -10
atmosphere (normal)	kilo pascal (kPa)	1.013 25 X E +2
bar	kilo pascal (kPa)	1.000 000 X E +2
barn	meter^2 (m^2)	1.000 000 X E -28
British thermal unit (thermochemical)	joule (J)	1.054 350 X E +3
cal (thermochemical)/cm^2	mega joule/m^2 (MJ/m^2)	4.184 000 X E -2
calorie (thermochemical)	joule (J)	4.184 000
calorie (thermochemical)/g	joule per kilogram (J/kg)*	4.184 000 X E +3
curie	giga becquerel (GBq) †	3.700 000 X E +1
degree Celsius	degree kelvin (K)	$t_K = t°_C + 273.15$
degree (angle)	radian (rad)	1.745 329 X E -2
degree Farenheit	degree kelvin (K)	$t_K = (t°_F + 459.67)/1.8$
electron volt	joule (J)	1.602 19 X E -19
erg	joule (J)	1.000 000 X E -7
erg/second	watt (W)	1.000 000 X E -7
foot	meter (m)	3.048 000 X E -1
foot-pound-force	joule (J)	1.355 818
gallon (U.S. liquid)	meter^3 (m^3)	3.785 412 X E -3
inch	meter (m)	2.540 000 X E -2
jerk	joule (J)	1.000 000 X E +9
joule kilogram (J/kg) (radiation dose absorbed)	gray (Gy)*	1.000 000
kilotons	terajoules	4.183
kip (1000 lbf)	newton (N)	4.448 222 X E +3
kip/inch^2 (ksi)	kilo pascal (kPa)	6.894 757 X E +3
ktap	newton-second/m^2 (N-s/m^2)	1.000 000 X E +2
micron	meter (m)	1.000 000 X E -6
mil	meter (m)	2.540 000 X E -5
mile (international)	meter (m)	1.609 344 X E +3
ounce	kilogram (kg)	2.834 952 X E -2
pound-force (lbf avoirdupois)	newton (N)	4.448 222
pound-force inch	newton-meter (N·m)	1.129 848 X E -1
pound-force/inch	newton/meter (N/m)	1.751 268 X E +2
pound-force/foot^2	kilo pascal (kPa)	4.788 026 X E -2
pound-force/inch^2 (psi)	kilo pascal (kPa)	6.894 757
pound-mass (lbm avoirdupois)	kilogram (kg)	4.535 924 X E -1
pound-mass-foot^2 (moment of inertia)	kilogram-meter^2 (kg·m^2)	4.214 011 X E -2
pound-mass/foot^3	kilogram-meter^3 (kg/m^3)	1.061 846 X E +1
rad (radiation dose absorbed	gray (Gy)*	1.000 000 X E -2
roentgen	coulomb/kilogram (C/kg)	2.579 760 X E -4
shake	second (s)	1.000 000 X E -8
slug	kilogram (kg)	1.459 390 X E -1
torr (mm Hg, 0° C)	kilo pascal (kPa)	1.333 22 X E -1

*The gray (Gy) is the accepted SI unit equivalent to the energy imparted by ionizing radiation to a mass and corresponds to one joule/kilogram.

†The becquerel (Bq) is the SI unit of radioactivity; 1 Bq = 1 event/s.

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SECTION 1

INTRODUCTION

1.1 PURPOSE AND SCOPE

This research sought

The purpose of the research was to identify and develop concepts for realistic cost-effective enhancements of integrated battlefield (IB) training for the battalion task force and the associated brigade commander and his staff, which fully exploits, and is compatible with, the operational concept and capabilities of the U.S. Army National Training Center (NTC). This report describes the results, conclusions, and recommendations from research done in Tasks 10 through 18 of the Statement of Work (SOW) for the program. These tasks constitute Phase III, of a three phase program.

California. The

1.2 BACKGROUND

1.2.1 Overview of the NTC

The National Training Center (NTC) is an advanced, fully instrumented facility which provides tank and mechanized battalion level force-on-force and live fire training. It is the Army's highest priority training program. An initial operational capability in January 1982 provided for up to 125 instrumented players (tanks, armored personnel carriers, etc.) on a single range. Expansion to 500 instrumented players on two ranges was incorporated in early 1983. A live fire training range, using realistic and scorable targets, was incorporated in 1984. →(to p 5)

Figure 1 shows the instrumentation used in the engagement simulation in which all U.S. Army armored and mechanized battalions are trained in full scale field exercises against a live enemy especially trained and equipped to duplicate Soviet forces.

"Players" are tanks, armored personnel carriers, and other key equipment which are instrumented with the Multiple Integrated Laser Engagement Simulation (MILES) system and a transponder as part of the Range Data Measurement Subsystem (RDMS). MILES simulates direct fire weapon engagements using eye safe laser beams.

The RDMS provides constant tracking of players and continuously provides the location of players to the Core Instrumentation Subsystem (CIS). The CIS consist of 32 controller stations supported by four VAX 11-780 computers. At the work stations, controllers for each unit use

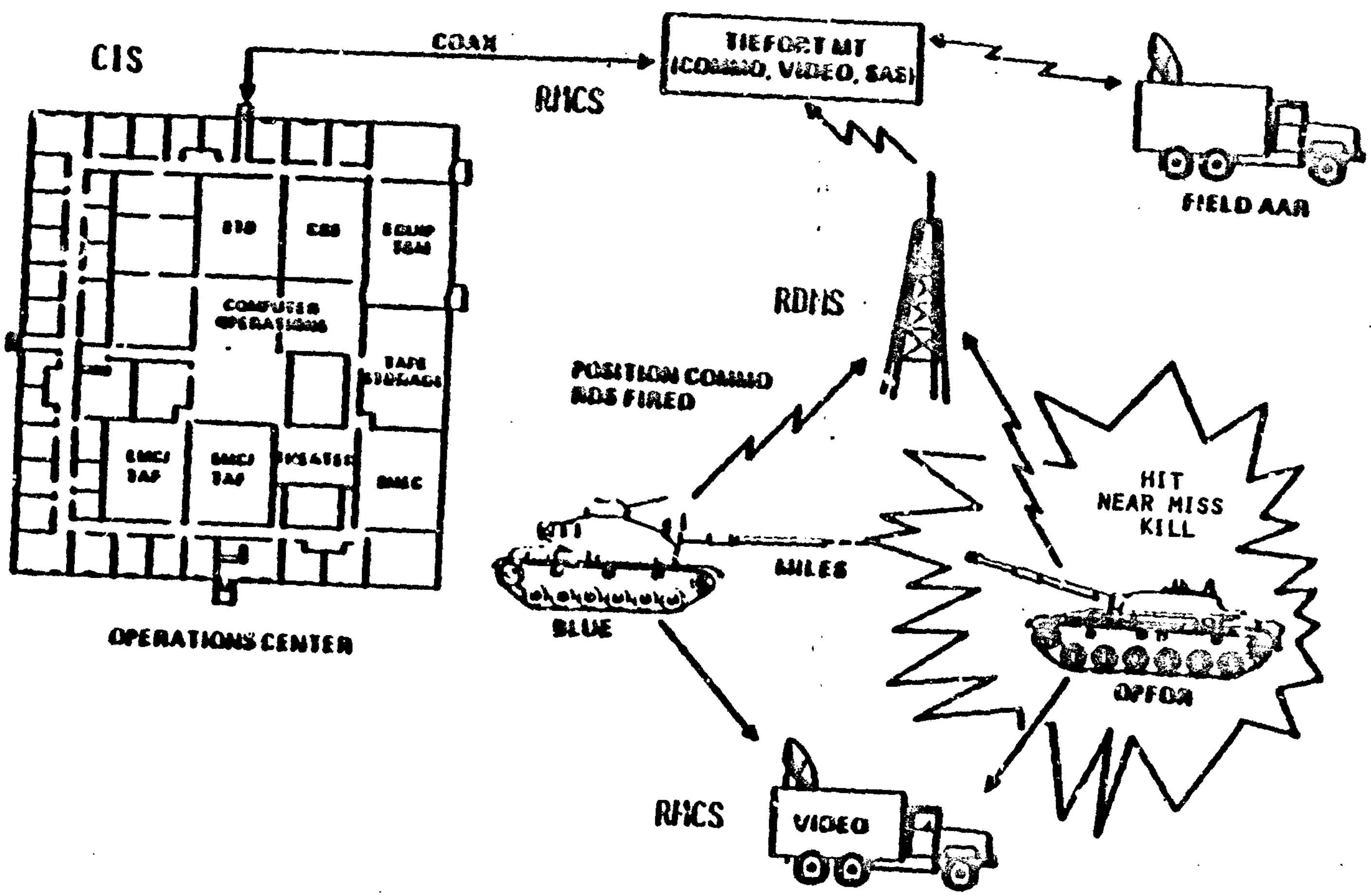


Figure 1. NTC engagement simulation instrumentation system.

interactive computer displays to select and to zoom in on areas of interest. Various terrain attributes, control messures, and player resolutions can be selected, depending on what the controller needs to know at the moment for real-time Exercise Monitoring and Control (EMC) and near real time Training Analysis and Feedback (TAF).

In the CIS, after action reviews (AARs) are prepared in the form of digital data playback and video tapes. AARs provide critiques of ongoing training exercises, which enhance the lessons learned in the experiential training. Field video teams produce live video tapes of the action on the ground to enhance AARs. Mobile AAR vans move into the field to provide AARs on site with minimum interruption of training. Video and audio information is beamed from the CIS to these vans via microwave.

Field controllers with each unit assist in the exercise control, and evaluation of troops. Field controllers are linked to the CIS by radio. Communications throughout the area between all subsystems are provided by the range measurement control subsystem (RMCS). Figure 2 shows the interfaces between the subsystems and components of the NTC.

1.2.2 Overview of the Three Phases of the DNA Integrated Battlefield (IB) Research Program

In its present configuration the NTC emphasizes conventional warfare training. Tactical nuclear and chemical warfare is included on a very limited basis using controllers in the CIS and the field to estimate and provide information on battalion task force performance in an IB environment (nuclear and chemical) using manual means. DNA and the U.S. Army have recognized the need for the NTC to provide more realistic IB training support which combines conventional, nuclear, and chemical warfare.

At the individual soldier level, such training must include realistic and timely environment and effects cues and assignment of casualties resulting from the IB environment. Specialists must be trained to utilize radiacmeters, dosimeters, and chemical alarms on their own intiative, without being artifically cued, and provide results in appropriate reports. At the command and staff level, training must include timely and consistent inputs from, and interactions with, subordinate, adjacent, and higher units and opposing forces. This provides the basis for the specialized, and often time critical, command and staff actions essential to success in tactical nuclear and chemical warfare.

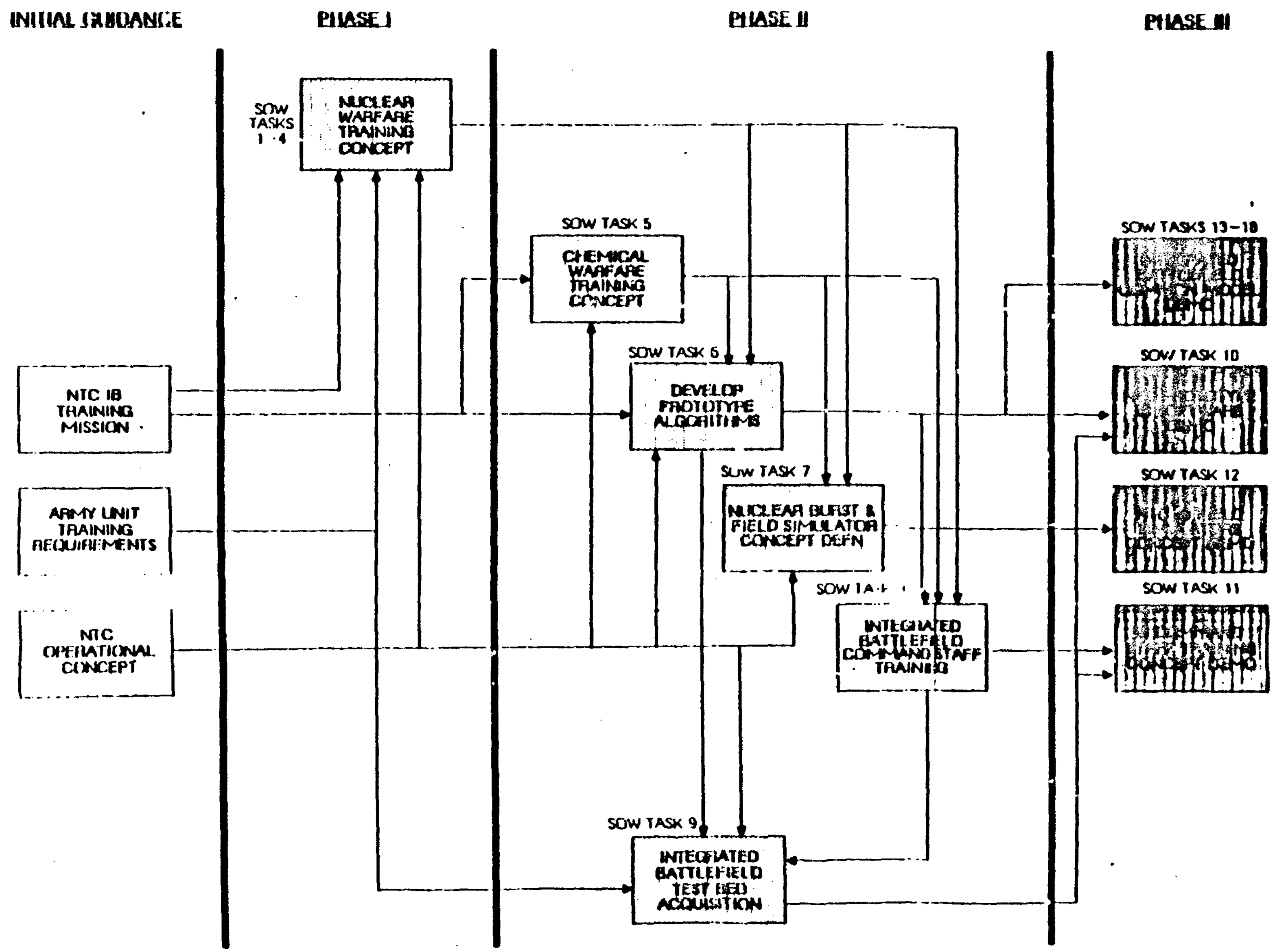


Figure 2. Research phases and tasks.

To achieve this essential enhancement of the NTC IB training, DNA (in cooperation with the U.S. Army Training and Doctrine Command (TRADOC) and the NTC Project Office) funded a phased research program to identify training requirements, develop and evaluate training system concepts, design prototype systems, and demonstrate proof-of-principles and prototype IB capabilities. Figure 2 presents an overview of the research phases and the associated tasks in the contract SOW.

Phase I research by SAIC developed a concept for nuclear warfare training at the NTC. The research was performed in SOW Tasks 1 through 4 and is documented in Nuclear Environments and Effects Research for the National Training Center, DNA-TR-81-207, 2 December 1982. Conclusions from Phase I research provided inputs to the Phase II research effort.

The Phase II research effort by SAIC developed a parallel chemical warfare training concept for the NTC (SOW Task 5); designed prototype nuclear and chemical environment and effects algorithms (SOW Task 6); provided a nuclear burst simulator preliminary design and design concepts for six types of field simulators (SOW Task 7); developed an IB command and staff training concept (SOW Task 8); and acquired an IB test bed (SOW Task 9). The results of this research are documented in Integrated Battlefield Research for the National Training Center, SAIC, 1 April 1984. (DNA-TR-84-129-V1-5). Conclusions from Phase II research provided inputs to Phase III.

Phase III, for which this is the final report, provides the following:

This study includes:

- an NTC compatible software system which models nuclear and chemical environment and effects, and provides the necessary interactive display and controls (SOW Task 10),

- a proof-of-concept demonstration of an IB command and control capability which provides for concurrent integrated training of battalion and brigade command staffs in which both real and notional (simulated) players are engaged in combined Field Training Exercise (FTX) and Command Post Exercise (CPX) (SOW Task 11),

and

- an analysis of technical and operational impacts of proposed nuclear and chemical field simulators on NTC training, and a preliminary design of selected

field simulators, and an associated common transmitter to control them (SOW Task 12), and

- six related tasks (SOW Tasks 13 through 18) supporting the Army Combined Arms Operations Research Activity (CAORA) at Ft. Leavenworth in developing a common Army training simulation ARTBASS which includes the play of realistic nuclear and chemical warfare.

These eighteen research tasks constitute an evolving coordinated effort which has identified and developed training concepts and provided prototypes of hardware, software, and personnel procedures. In concert with the original DNA/TRADOC agreement, DNA has supported research to develop and demonstrate key IB capabilities. TRADOC is now in the process of funding implementation efforts to incorporate selected IB capabilities into the NTC Instrumentation System.

1.3 ORGANIZATION OF THE REPORT

This report follows the organization of the SOW for Phase III of the NTC IB Effects Research effort. Details of the research have been provided in separate research reports which, in many cases, have been submitted for review and approved during the course of the research as they were completed. Reports which describe the approach, results, conclusion, and recommendations for each major task are included as appendices to this final report. A cross reference of major SOW tasks and the appendices to this report is presented in Table 1.

Table 1. Major SOW tasks and associated reports.

SOW Task 10 - IB Training Software System

Report Title	Appendix
"Report on the Analysis of Nuclear Algorithms for the National Training Center (NTC) and the Combined Arms Tactical Training Simulator (CATTS)" SAIC, September 1983	A
"Requirements Design Specification for the Addition of Nuclear and Chemical Capabilities to the National Training Center (NTC) Core Instrumentation Subsystem (CIS)" SAIC, December 1984	B
"NTC Chemical Model Algorithm Description" SAIC, December 1984	C

SOW Task 11 - IB Command and Control Capability Demonstration

Report Title	Appendix
"Functional Requirements for the National Training Center (NTC) Integrated Battlefield Command and Control Simulation (IBCCS) System" SAIC, December 1983	D
"Requirements Design Specification and Demonstration Report for the Exercise Coordination and Control (ECC) Demonstration System" SAIC, November 1984	E

SOW Task 12 - Nuclear and Chemical Measurement and Effects Simulators

Table 1. Major SOW tasks and associated reports (Concluded).

Report Title	Appendix
"Technical and Operational Impacts of Field Simulators on the National Training Center", SAIC, 17 December 1984	F
"Capability of Off-the Shelf Pagers to Receive Transmissions in the Operational Areas of Fort Irwin, California", SAIC, 26 October 1984	G
"Designs of Nuclear and Chemical Field Simulators for the National Training Center" SAIC, 21 December 1984	H
SOW Task 13 - Common IB Feasability Assessment	
"Feasability Study of Transferring ARTBASS Code from Perkin-Elmer/Lexidata System to VAX/DeAnza System" SAIC, 21 December 1984	I
SOW Task 14 - Requirements Analysis	
"Division/Corps Training Simulation System" SAIC, 21 Decem-1984	J
SOW Task 15 - NUC/CHEM Software Integration, SOW Task 16 - Common Model Design and Integration, and SOW Task 17 - Common IDC Design and Integration	
"ARTBASS Conversion Design and and Results" SAIC, 21 December 1984	K
"Requirements Design Specification for Addition of Nuclear and Chemical Capabilities to the Army Training Battle Simulation System (ARTBASS)" SAIC, 21 December 1984	L

SECTION 2

RESULTS OF RESEARCH

2.1 SOW TASK 10: INTEGRATED BATTLEFIELD (IB) TRAINING SOFTWARE SYSTEM

Under Phase II of this contract, requirements were defined and a prototype was implemented for an NTC nuclear and chemical model. Based upon the results of this previous work, a complete operational prototype IB software system was developed, tested, and demonstrated within the NTC operational software context (i.e., the 500 player configuration with live fire range command and control software integrated) to facilitate subsequent installation at the NTC.

2.1.1 SOW Task 10.1: Nuclear/Chemical Model Modification

SAIC worked closely with both DNA and TRADOC to define the necessary modifications and extensions of nuclear and chemical algorithms developed and demonstrated under Phase II of this contract.

As part of this analysis effort, a comparison of the nuclear and chemical algorithms used for the Phase II demonstration was conducted with those developed for use in the CATTS model to determine which algorithms should be incorporated into ARTBASS (the U.S. Army's battalion command staff training device). Since ARTBASS is the accepted BN CPX model, it was necessary to ensure that both NTC and ARTBASS utilized the same basic nuclear and chemical models in order to provide consistent results when real and notional unit information was combined to form a single, coordinated battle. Since the CATTS algorithms were to form the basis for the ARTBASS nuclear and chemical models, this effort was intended to refine the CATTS algorithms such that the resulting set could be used for both NTC and ARTBASS. The results of this analysis are presented in Appendix A.

As a result of SAIC's analysis efforts, and in accordance with inputs from DNA and TRADOC/NTC, necessary modifications and extensions of the nuclear/chemical model were identified and defined in the Requirements Design Specification for the Integration of Nuclear and Chemical Models into the NTC CIS (Appendix B). These updates included the following:

1. The nuclear model was integrated into live fire baseline software instead of the 500 player software.

2. The discussion of how to implement the requirement to cross segment boundaries was refined.

3. An equation for determining ultimate casualties was added, based upon an algorithm defined for CATTS.

4. Logic was added which provides for generation of multiple burst/multiple fallout patterns.

5. Blast effect changes were added for calculating overpressure kills.

6. The height of burst definition was changed to be a selection (air/ground).

7. 50 and 100 KT yields were added to the Nuclear Event Definition interactive menu.

8. Nuclear and chemical event logs were developed in order to automatically log an event and indicate status of executed, cancelled, or not executed.

9. The accumulated radiation and radiation dose rate over time reports were updated to provide information by posture category.

10. The time for calling the nuclear model was updated from every minute to every two minutes.

11. Nuclear and chemical event definition menus were made available at all times.

12. The Control Measure interactive menu was updated to include the definition of nuclear and chemical markers.

13. The Player Resurrect interactive menu was updated to include the capability of specifying whether a player was resurrected for resupply or accidental kill.

14. A limit of ten players was defined for recommendation alerts.

15. The requirements for defining multiple nuclear bursts was expanded to detail that no shock enhancement effects would be calculated and only instantaneous shock propagation and thermal casualty effects would be calculted.

16. The posture for air players was defined as in the open.

17. The parameters the model sends to the interactive display component for generation of nuclear and chemical prediction displays was updated.

18. The definition of a contaminated player was changed to indicate that the player must have at least 1 rad to receive a contamination shroud.

19. A button was added to the graphics tablet for chemically contaminated players.

20. The following NTC interactive menus were changed: Control Measures, Exercise Segment Definition, Player Kill, and Player Resurrect.

21. Appendices were added to the document to define nuclear and chemical algorithms.

22. The Chemical Contamination Report was developed to provide long term casualty contamination data by unit for each posture category.

23. The Chemical Event Definition interactive menu was expanded to include rockets as an additional delivery method. The operator was also provided with the capability of defining the type of attack (i.e., casualty, obstacle, or harrassment) for each event.

24. A new chemical protection condition for personnel wearing only a mask/hood (open or closed) was added to all processes in which MOPP is a factor.

25. The unit in a Contaminated Area alert was added.

26. The chemically contaminated area calculation was redefined.

27. The Chemical Effects Casualty Recommendation alert was modified.

28. The Chemical Event Cancellation capability was provided.

29. The Accumulated Radiation Report was updated to include contamination data for long term casualties.

2.1.2 SOW Task 10.2: Integration of the Nuclear Model and NTC CIS Software

As part of this task, the following activities were performed:

1. All data structures required for the production of statistical reports were provided.
2. The interactive menu capability required for operator control of nuclear training play at the NTC was provided.
3. Graphical displays which depict the immediate effects and fallout contours which result from a defined nuclear event were incorporated into the baseline NTC software.
4. Required nuclear event alerts were provided.
5. Required alphanumeric statistical and graphical reports were provided.
6. Degradation and restart capabilities were added to the nuclear model.

2.1.3 SOW Task 10.3: Integration of the Chemical Model and NTC CIS Software

The algorithms selected for the chemical model are based upon CATTS recommendations. Recognized, accepted chemical model algorithms were utilized and adapted to efficiently operate in the NTC environment. The PROBIT function from the CHEMCAS model was selected for casualty computations, a vapor diffusion computation from the PORTION model was selected for calculation of downwind hazard and residual effects of persistent agents and the vapor diffusion computation from the Sutton-Calder model was used for calculation of downwind hazard from nonpersistent agents. Discrepancies found in the CATTS chemical model, were corrected.

A flexible, structured approach which was utilized to facilitate maintenance and updating. Figure 3 depicts the approach used in developing of the chemical effects model. A flexible, structured approach was used which is amenable to maintenance and updating. A description of the algorithms used for the chemical model is contained in Appendix C, Chemical Model Algorithm Description.

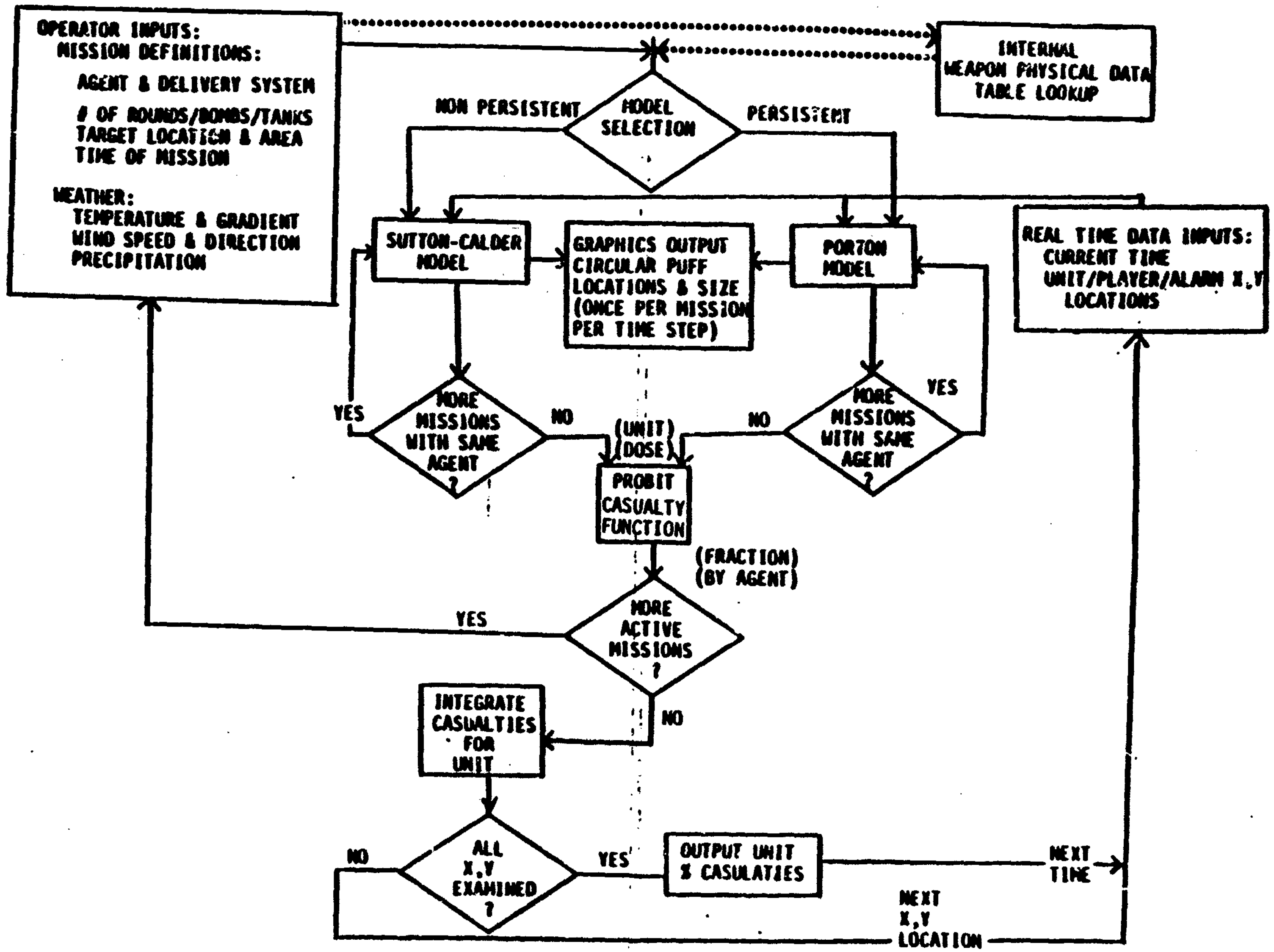


Figure 3. Chemical model approach.

As part of the integration task, the following tasks were performed:

1. The chemical model was rewritten to reflect the new algorithms and requirements determined since Phase II of the contract.

2. All data structures required for the production of statistical reports were provided.

3. The interactive menu capability required for operator control of chemical training at the NTC was provided.

4. Graphical displays which depict chemical contamination resulting from a defined chemical event were incorporated into the baseline NTC software.

5. Required chemical event alerts were provided.

6. Required alphanumeric statistical and graphical reports were provided.

7. Degradation and restart capabilities were integrated into the chemical model.

2.1.4 SOW Task 10.4 NTC Integrated Battlefield Training Concept Demonstration

The Integrated Battlefield Software System Development and Demonstration effort was concerned primarily with the integration of nuclear and chemical models into NTC software and the demonstration of how nuclear and chemical models can be used to assist training at the NTC.

Separate demonstrations were provided for the nuclear and chemical model integration efforts. The nuclear demonstration was held in February 1984 and the demonstration of the chemical model occurred in November 1984. (The demonstration of the nuclear model was repeated with the chemical model demonstration.) Each demonstration included: (1) a canned history which demonstrated the concept for nuclear and chemical play at NTC which efficiently demonstrated all requirements in an orderly, accountable manner; and (2) a participatory (interactive) demonstration which provided for hands-on experience and execution of various software options not available in a closed history.

2.2 SOW TASK 11: INTEGRATED BATTLEFIELD COMMAND AND CONTROL CAPABILITY DEMONSTRATION

The intent of the NTC IB command and control capability is to support the training of brigade and battalion command staffs in an IB environment at the NTC through the combination of command post exercises (CPXs) and field training exercises (FTXs). Functional performance requirements for the battle simulation software, required to support both the CPX training and higher echelon role playing, have been identified. The requirements for combining data from both live and notional units have also been defined and a prototype system capable of demonstrating this concept has been developed.

Under Phase II of this contract, an initial concept definition was provided for the IB command and control capability, as shown in Figures 4 and 5. This approach served as the basis for continued design of the system and provided a broad set of requirements on which to base the prototype software developed for the demonstration system.

2.2.1 SOW Task 11.1: Design and Develop IB C3I Battle Simulation Logic

The goal of this effort was to provide a solution, in the form of functional performance requirements, to the problem of effective IB experiential training of brigade and battalion field commanders and their staff officers participating in CPX training. Nuclear and chemical processing requirements were defined and modeling requirements for development of a macrolevel simulation to augment division-level role playing were defined. The concept for utilizing the NTC AAR capability for providing feedback to these participants was also developed.

In order to provide a consistent training environment, a basis for vertical compatibility of models (e.g., the battalion level models can be used in conjuction with Corps/Division models), an ease of maintenance, and a flexibility for use in various training applications, a common training model was desirable for use at the NTC. Since battalion-level simulations for CPX training have already been developed by the U.S. Army, a survey of available models (which included CATTS, the NTC Test Support Driver (TSD), and ARTBASS) was conducted. Based upon inputs from DNA, TRADOC, and CAORA, ARTBASS was selected as the best candidate for use as the common training model; therefore, the nuclear and chemical models have been added to that software.

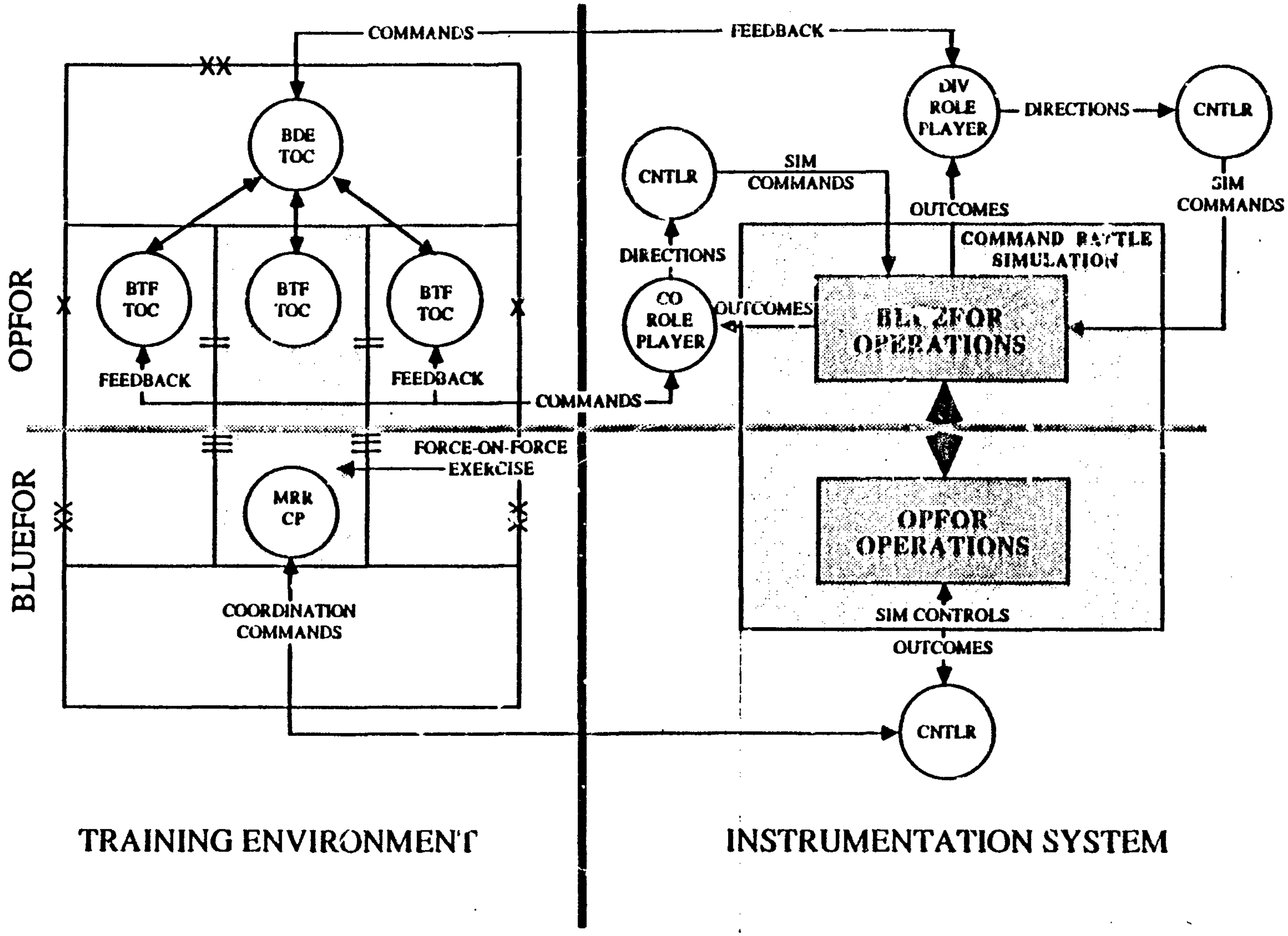


Figure 4. Overview of brigade command staff training concept.

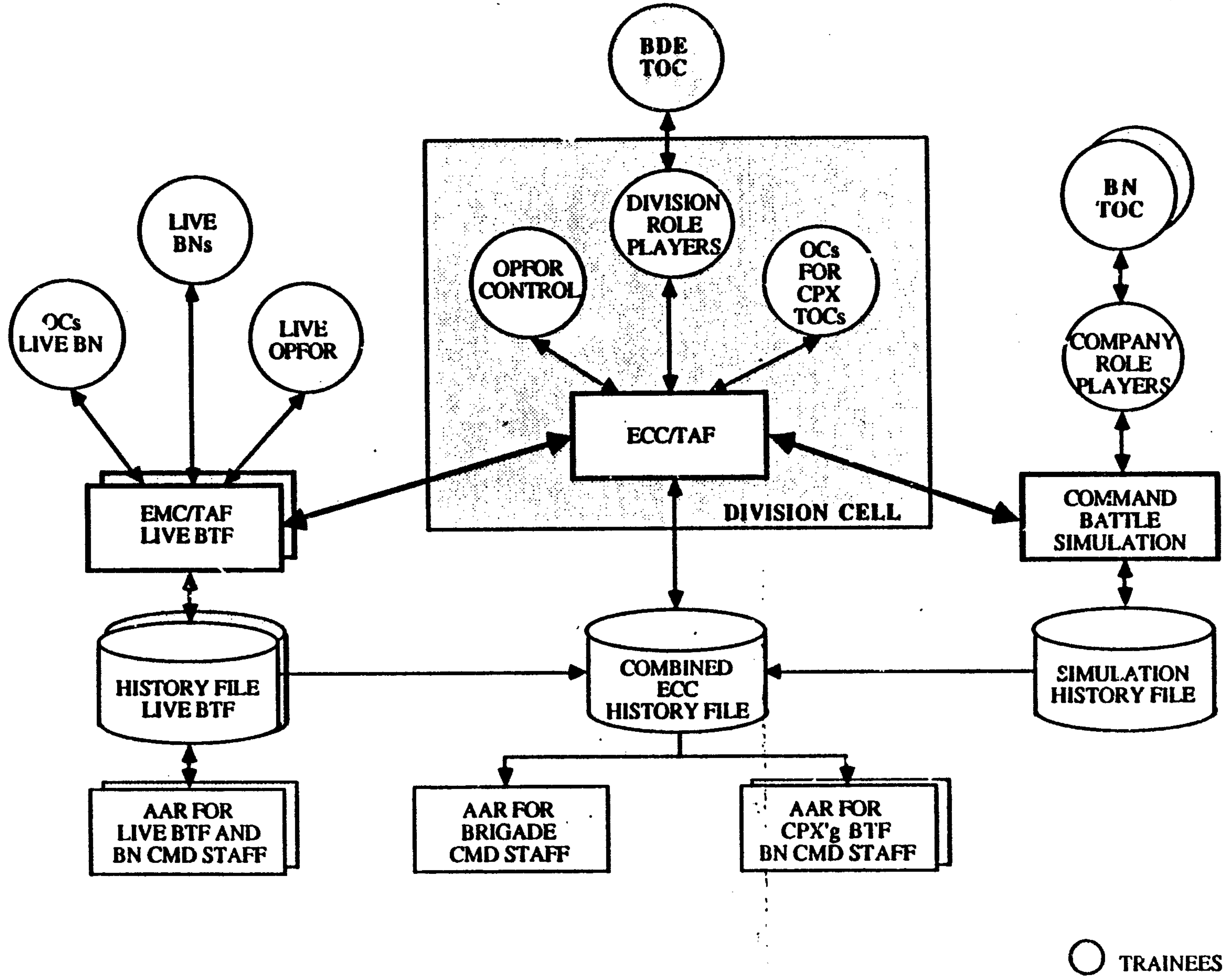


Figure 5. Data flow for brigade command staff training concept.

To support NTC requirements, the NTC and ARTBASS software utilized the same nuclear and chemical environment and effects algorithms (models). In order to accommodate the unique requirements of NTC and ARTBASS, the casualty computations (i.e., IB effects) were restructured and tailored to meet NTC and ARTBASS needs. Analyses were performed to ensure that results from these models were consistent with one another.

2.2.2 SOW Task 11.2: Design and Develop IB C3I Interactive Display and Control Interface

Interactive control of the battle simulation model IB software was designed and developed to provide controller and role player interaction with the system. In addition to designing and developing the interactive display and control software for the common model enhancements, an interface was designed for control of the Exercise Coordination and Control (ECC) station. This station is responsible for receiving inputs from both the live and simulated exercises and presenting this information in support of Brigade staff training and Division level role playing. The information needed to coordinate the brigade level exercise and to provide meaningful AARs to brigade and battalion command staffs is provided at the station. Appendix D, "Functional Requirements for the National Training Center (NTC) Integrated Battlefield Command and Control Simulation (IBCCS) System", presents the requirements for this man-machine interface (MMI).

2.2.3 SOW Task 11.3: Implement IB C3I Capability

The "Requirements Design Specification and Demonstration Report" for the Exercise Coordination and Control (ECC) Demonstration System describes the software to support the demonstration required in SOW Task 11.3. This document was submitted to DNA and discussed with both DNA and TRADOC at several In Process Reviews (IPRs) prior to implementation of the software.

To support a demonstration of the capability, SAIC developed a means of reading raw data tapes from actual NTC exercises (to serve as data drivers for a "live" NTC history), developed an ARTBASS scenario and combined these inputs to form an ECC history database (i.e., both real and notional players).

The demonstration was held at the NTC software development facility at SAIC in La Jolla instead of Ft. Irwin, by direction of DNA and TRADOC, to avoid interference with normal NTC operations. The demonstration was held 20 November 1984 and consisted of two parts: a closed ECC history which could be used to demonstrate the basic

concepts and a participatory demonstration which allowed for hands-on experience and demonstration of certain features which are unavailable in a closed history. All required features were sucessfully demonstrated.

2.3 SOW TASK 12: NUCLEAR AND CHEMICAL MEASUREMENT AND EFFECTS SIMULATORS

Previous work performed in Phase II provided a preliminary design of a nuclear burst cue simulator and concept definitions for six measurement and effects field simulators.

In the overall field simulator concept, as shown in Figure 6, the simulated nuclear and chemical environments and their effects on personnel and equipment are computed and stored in the Computational Component (CC) of the CIS. The simulated radiation rate and chemical environment is computed throughout the exercise areas at least every two minutes. In addition, accumulated dose levels, contamination, and degradation of players and platoon sized units are computed and stored in the CC at this same rate. These environments are then used to activate or generate simulated environmental measurements for field simulators.

The CC will also store the correlation of units with field simulators and their address codes. Nuclear and chemical environments and effects information will be filtered to identify that information which relates to units having field simulators. These units' designations will then be linked with the address codes of the field simulators for each unit, and the field simulator control messages will be formatted to describe the environment or effects. Each message, consisting of a field simulator address and instructions, will be passed from the CC to the Simulator Transmission Module (STM).

The STM will consist of a cable or RF link to relay locations, (i.e., Goat Mountain, LFA1, and Tiefort Mountain) and from there via an RF link to all simulators within the manuever areas. The STM link will be one-way from the CC to the Simulator Field Modules (SFM). Each message will be sequentially sent to each of the relay stations to provide the best transmission reliability to the field simulators for all locations.

Based on previous research, the following six types of SFMs were considered:

- Radiacmeter

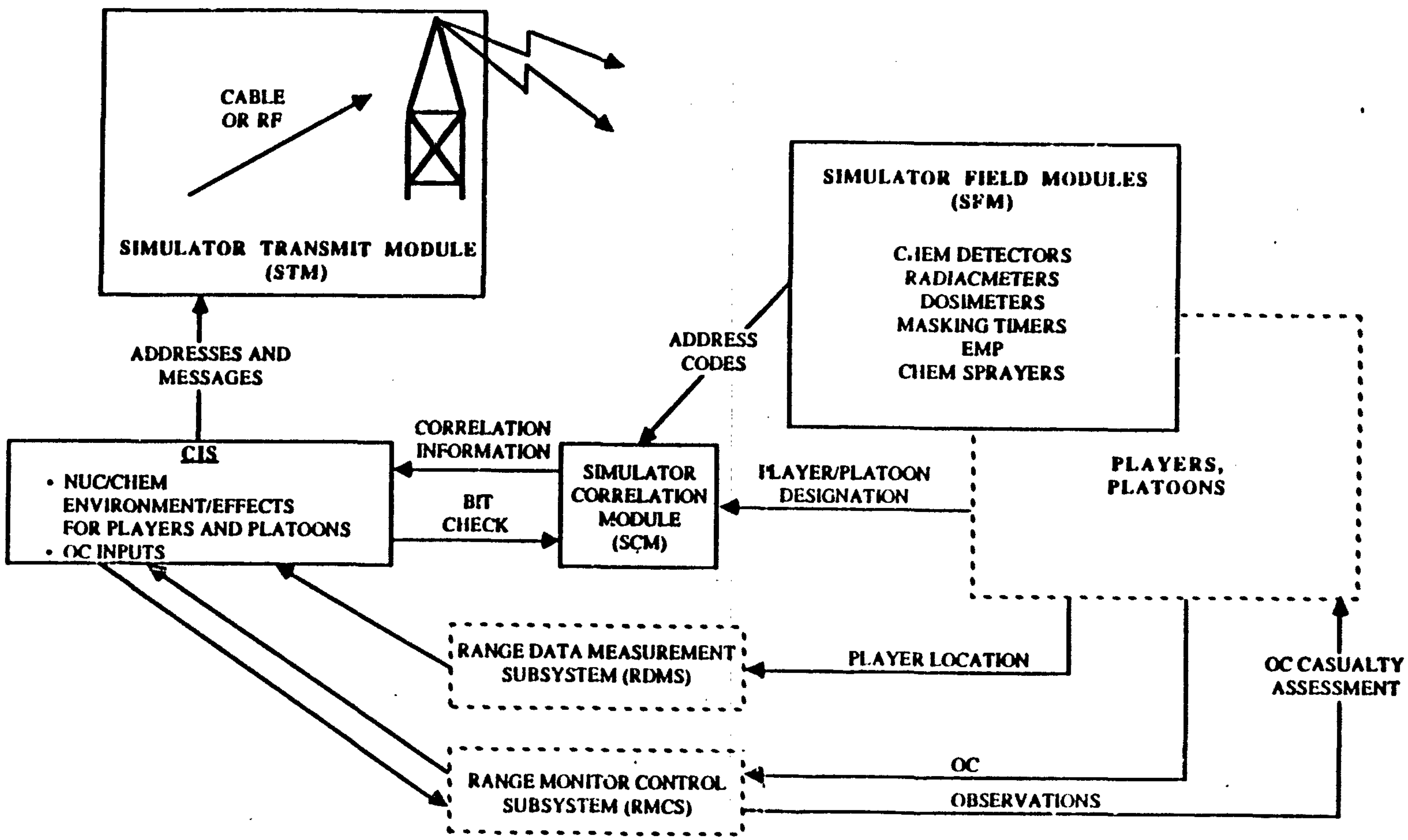


Figure 6. Overview of field simulator concept.

- Dosimeter
- Chemical Alarm
- Masking Timer/Casualty Indicator
- EMP Radio Interrupter
- Chemical Contaminant Simulant Sprayer

These simulators had been selected to provide realistic cues for environments and effects to satisfy current Army training objectives. The messages received via the STM will cause the SFMs to indicate the following environment and effects:

- Radiation rate at the location of the unit to which the radiacmeter simulator is assigned.
- Total radiation accumulated dose (since the dosimeter was last zeroed) for the unit to which the dosimeter simulator is assigned.
- Activation of the alarm signal at the chemical agent detector if the detector is in an area of chemical contamination.
- A kill signal for all members of each platoon which is in an area of chemical lethal concentration. A transducer on the mask provides a signal which interrupts the kill signal when the mask is worn.
- Disablement of radios which are operating within the area in which EMP would disable radios. The disablement can be reversed by a field controller.
- Release of a chemical simulant spray on tanks and APCs.

Correlation of unit/player identification and SFM address codes will be accomplished by field controllers before an exercise begins. Initially this will be done manually, as is currently done for player-to-B-unit assignments. As more field simulators become operational this will be done using the Simulator Correlation Module (SCM). The SCM design consists of a bar code reader, keyboard input, a data storage device, and an RF transmitter/receiver. For each company sized unit, a field controller will enter the unit designation via the keyboard or bar codes. He will then scan the type and address code of each field simulator assigned to the unit by use of the bar code reader. (Each

field simulator will have a bar code attached). After the information is collected, it will be transmitted to the CIS, via the SCM RF link, and entered into the CC.

Functions which are part of the current NTC are utilized in the field simulator operation. (These functions are indicated with dotted lines in Figure 6.) Player location for instrumented players will be tracked by the RDMS. This will provide the location of field simulators whose co-location with the players have been established using the SCM. Field controllers will observe players and provide information on their posture (e.g., inside or outside APCs) to the controllers within the CIS. Casualty recommendations for nuclear and chemical effects follow the reverse path, from the CC via CIS controllers to field controllers, who specify players to become casualties.

2.3.1 SOW Task 12.1: Identification and Analysis of Technical and Operational Considerations

2.3.1.1 Interface Analysis - SAIC identified and analyzed technical and operational issues associated with integrating IB field simulators into the NTC field instrumentation and in using the simulators in training exercises. This research was documented in the draft report "Technical and Operational Impacts of Field Simulators for the National Training Center" SAI, 1 February 1984. The report has been modified based on subsequent tests. The updated report is included in Appendix F of this report.

As part of this research SAIC identified interfaces of simulators with each other and with the NTC CIS, RDMS, RMCS, and with operational and control communications. Interface identification and relationships are summarized in an "N squared" diagram in Figure 2 on page 27 of Appendix F. All interfaces were found to be compatible.

A potential problem in required message rates was identified. This problem was resolved by including logic which would send new control commands to field simulators only when readings had changed by a threshold amount.

Analysis showed that the number of different codes required was between 15 to 18 per platoon. This is less than 5000 codes and well within the capability of the system under consideration.

2.3.1.2 Quantities of Field Simulators and Resources Required - The numbers of simulators required for operation at the NTC, including spares, replacements, and maintenance float were estimated. Resources required are identified in Section 2.0 of Appendix F. Quantities of simulators needed to concurrently train two battalions are in Table 2.

Table 2. Quantities of simulators required.

TYPE	OPERATIONAL QUANTITY	TOTAL QUANTITY	BASIS OF ISSUE
Radiacmeter IM 174	139	150	One per BLUEFOR Platoon and Spares
Dosimeter IM 93 or IM 185	307	340	Two per BLUEFOR Platoon and Spares
Chemical Alarm M-8	113	125	Two per BLUEFOR Company and Spares
Masking Timers/ Casualty Indicators			One per Trainee and and OPFOR Personnel and Spares
M 17 Type	1389	1550	
M 25 Type	753	850	
FMP	300	300	One per Tank/APC/ BMP/ZSU and Spares
Chemical Sprayer	300	300	One per Tank/APC/ BMP/ZSU and Spares

Requirements for maintenance and logistic support as well as resources for operations and maintenance are estimated in Section 2.0 of Appendix F.

2.3.1.3 Technical Issues - Technical issues associated with introducing and operating the proposed field simulators were addressed. These issues were identified as follows:

- Radio frequency (RF) transmissions constraints and coverage
- Timing constraints
- Computer capacity for adding similar requirements
- Masking simulator/casualty indicator feasability

Initial RF analysis indicated possible problems in being able to cover the entire operational area from a few transmission sites. To resolve this problem, a test was conducted which measured path losses throughout the operational area. Results of this test are found at the end of Appendix F. ("Electromagnetic Path Loss Survey for the Integrated Battlefied Research Study Program at Fort Irwin.") The test showed that there was considerable uncertainty about adequate coverage throughout the operational area. The question was resolved in a later test, described as part of the next subtask, which showed the candidate RF control system would provide good coverage throughout the area. (Reference Section 4.0 Appendix G).

Timing constraints showed the possibility of a problem in handling the required number of messages in a fixed time period. Analysis of message requirements showed that prioritization of messages by the software would satisfy timing constraints. (Reference Section 4.2 Appendix F.)

Feasibility analysis of the masking timer/casualty indicator showed that there was considerable development risk associated with the suggested masking concept. A transducer which indicates whether the mask is properly worn and which was based on pressure differentials, had been found inadequate by the Army Combat Developments Experimentation Command (CDEC). CDEC is experimenting with a temperature differential transducer, which shows promise, but is not fully developed. (Reference Section 4.4, Appendix F.)

2.3.1.4 Operational Issues - Operational issues associated with introducing and operating the proposed field simulators were also addressed. These issues were as follows:

- Training issues
- Effects on logistics

Training issues addressed included changes in trainee environment, training emphasis, realism, controller workload, and applicability of the chemical sprayer field simulator. Effects on logistics included changes and impacts on supply and maintenance. (Operational issues are documented in Section 5.0 of Appendix F.)

2.3.2 SOW Task 12.2: Design of Measurement and Effects Simulators

The research peformed in the preceding task was reviewed in briefings with the DNA Contracting Officer's Representative (COR) and the U.S. Army TRADOC NTC Program Manager. It was determined that based on the resource requirements projected in the research, further development of only three types of simulators should be pursued at this time. These were the chemical detector simulator, the radiacmeter simulator, and the dosimeter simulator. Since the entire concept depended on the ability to reliably transmit messages to the field simulators, the first design task was to develop a common control system, a prototype of which could be tested at Fort Irwin under realistic operational conditions. The remaining effort focused on the design of the three types of field simulators indicated above.

A systems engineering approach was used for the preliminary field simulator design efforts. The process consisted of identifying the functions to be performed (based primarily on earlier steps in the research), deriving required and desired characteristics, identifying and evaluating design alternatives, and developing the selected design. Appropriate limited exploratory tests were conducted to reduce design risks as necessary.

Details of the design process and of the designs are provided in Appendix I to this report. Results are summarized in the remainder of this subsection.

2.3.2.1 Design of the Common Control System

The function of the common control system is to format and transmit digital messages to the activating elements in the field simulators. The common control system interfaces with the CIS computer and the parts of the simulators which cause a detector activation or a needle reading. Message content, reliability, useability (in terms of getting permission to operate in the RF spectrum), size, and maintainability were the driving characteristics of the design.

A commercial off-the-shelf paging system with the required performance characteristics was identified. Field strength tests had been conducted in the previous subtask to confirm that the system would work at Fort Irwin under the conditions required. The test left considerable doubts in interpretation, due to problems in identifying the real sensitivity of the pager devices; therefore, a further test was conducted in the design phase using the actual candidate hardware. This test, which is documented in Appendix G, showed that the paging system, using three transmission sites, could effectively cover the entire Fort Irwin operational areas of interest. The process of preparing for the test also provided valuable information on allowable power levels, frequencies, and procedures for obtaining permission to transmit in the Fort Irwin area.

The common control system design consists of the following elements: (See Figure 7):

- Encoders and Base Station Controllers
- Transmitters
- Antennas
- Receiver/Decoders

The encoders and base station controllers interface with the CIS computer via RS232 ports. These elements receive messages from the CIS computer and format them for transmission to the pagers. They also remotely control the base station radio frequency (RF) transmitters. For these elements a Motorola MODEN Plus Microprocessor Controlled Paging Encoder, Model EOPLS200-T with full Alphanumeric Expansion was selected. One MODEN is planned for each transmitter.

The MODENs connect to the transmitters via conditioned telephone transmission lines from the CIS to the three transmission sites: Goat Mountain, LPA 1, and Mount Tiefort. These lines exist and are maintained by Amex Systems Incorporated. In the design it was assumed that space on these lines would be available as government furnished equipment (GFE).

MODENs will also be used to convert the signal from the transmission line to the Golay code to be sent via RF to the pagers.

The transmitters selected were the same types as used in the tests. These are the standard commercial Motorola PURC Radio Paging Station, Model Series C73JZB, operable at 132-174 Mhz with 50 to 100 watts output. The transmitters

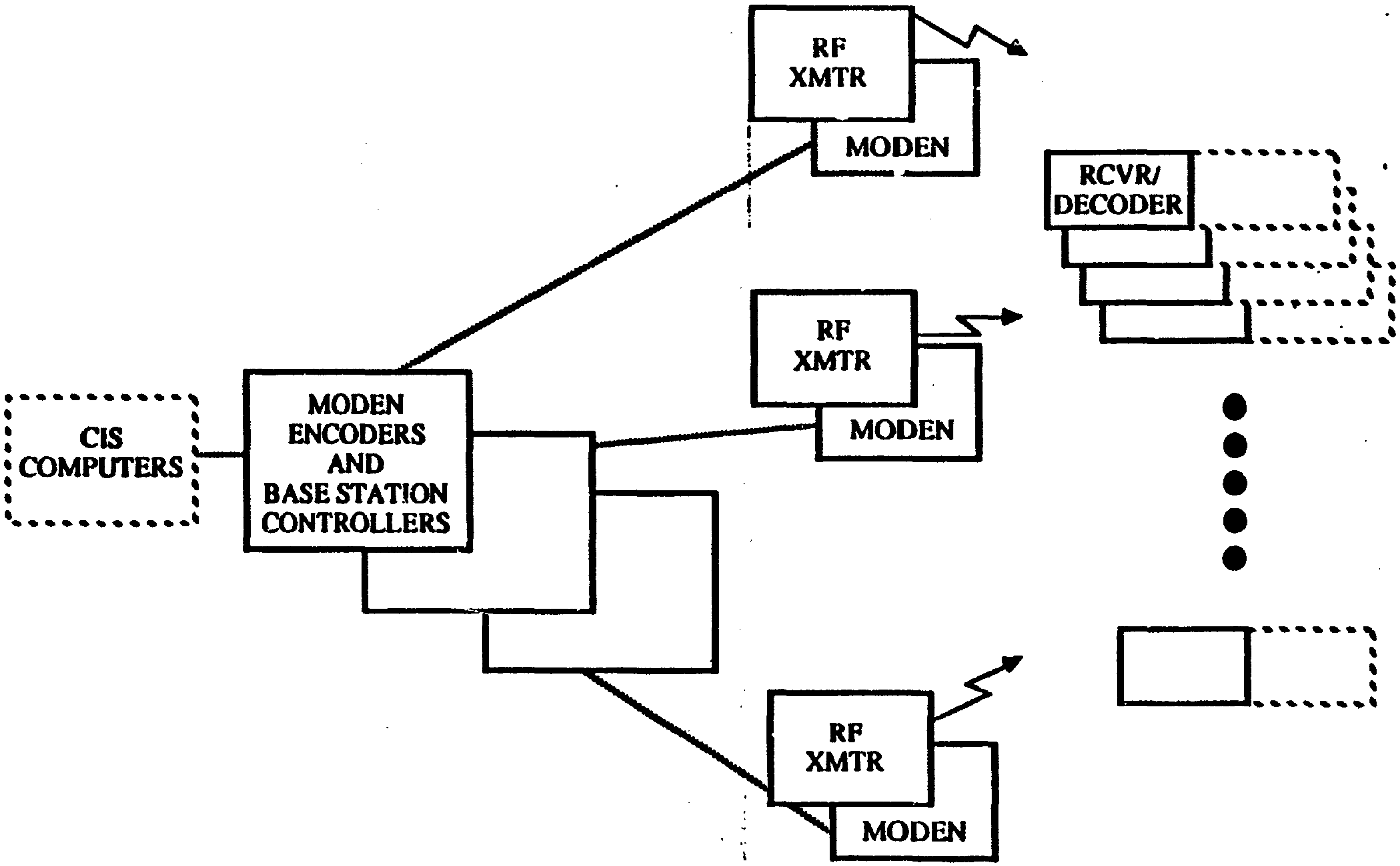


Figure 7. Common control component of the field simulator subsystem.

will be operated at minimum power with the antenna lead line attenuating the power to 25 watts. Transmitters will be grounded and installed in weather proof shelters. They will operate unattended.

An antenna will be used which radiates power downward and into the areas of interest. Commercial radiating elements are used, with a specially designed supporting mast. The commercial product is a Decibel Products Incorporated, Broad Band Directional Gain Antenna, DB-224E, using the DB-224 side mount kit. The antennas will be permanently installed, with appropriate lightning protection.

Two types of commercial pagers will be used as receiver/decoders. Readouts and alarms ("beepers") will be diconnected, and the leads will be connected to circuit boards which convert the receiver/decoder code to a code which is useable to control the chemical detector activation or the readings on meters. These outputs are the interface of the common control system and the specific simulators discussed in the following sections.

A pager with a digital readout will be used with the radiacmeter and dosimeter simulators. This will be a standard commercial pager, the Motorola BPR 2000 Display Radio Pager, Model AO3BGC4661. A pager with simple notification alarm will be used in the chemical detector simulator. This will be a Motorola ENVOY Tone Pager, Model AO3GAC4668AA. The first pager is about the size of a pack of cigarettes. The second is about half that size. An efficient conformal antenna is included within each volume; prototype tests will determine if a larger antenna is needed. Both pagers use size "AA" batteries.

2.3.2.2 Design of the Chemical Detector Simulator

The Chemical Detector M43 is used to warn troops of the presence of toxic chemicals. It has an internal audible alarm and connectors for field wires by which it can activate the Remote Alarm, M42. The chemical detector field simulator will provide the capability to activate by remote control either the internal alarm or the remote alarm.

The detector fits into the mounts on different vehicles, and the simulator will also fit in these same mounts.

There are several operational and maintenance functions which must be performed to successfully employ the M43. The simulator should provide at least the operational functions which affect all troops in the unit (e.g., activation of the chemical alarm and sounding the chemical alarm in a test).

Simulation of the maintenance functions will also be useful in training specialists but are not essential (e.g., replacing the liquid.)

The initial design was based on utilizing an M43 detector, combined with the means to spray a harmless chemical on the detector to cause it to react as it would to an actual chemical warfare agent. This approach provides training in all operational and maintenance functions and would be relatively low cost. The design path showing the alternatives considered and selected for this design is shown in Figure 8.

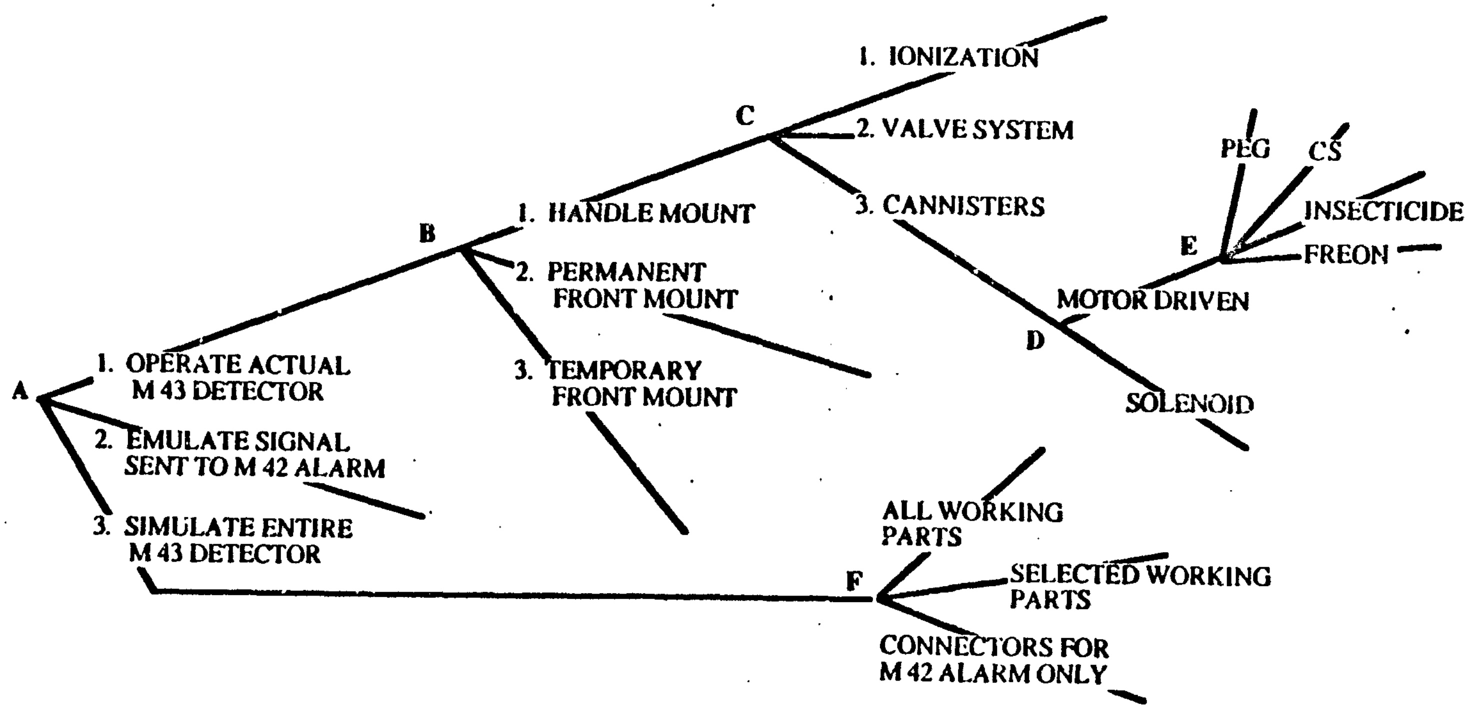
The proposed design utilizes an on/off type pager (Motorola ENVOY model). The receiver/decoder and the spray cannister and spray control are mounted in an enlarged carrying handle, which easily replaces the detachable handle on the M43. (See Figure 9.)

It was difficult to obtain actual U.S. Army equipment needed to test the concept. However a confirmation test was conducted in a battalion area at Fort Irwin. The test showed that none of about twenty chemicals tested would effectively set off the detector. The test was based on only one detector, but it indicated that the basic concept of using a harmless chemical gas with an actual detector might be unworkable. The lack of detectors in the battalion also raised the question of an adequate number of detectors being available for training. Therefore, an alternate design was developed for a simple simulator which provides only the minimum required operational functions.

Characteristics of the alternate design are as follows:

- Operating instructions plate
- Handle and strap similar to those on the M43
- Same form as M43 to conform to vehicle mounts
- Internal alarm with volume control
- Same batteries as the M43
- Capabiliy to attach and operate M42 Remote Alarm
- Capability to select internal and/or remote alarm activation

This detector simulator design also used the on/off Motorola pager described above. The design is illustrated in Figure 10.



A. OPERATIONAL CONCEPT
B. MONITORING CONCEPT
C. ACTIVATION CONCEPT
D. OPERATION MECHANIZATION
E. SPRAY AGENT
F. DEGREE OF DETAIL

Figure 8. Path for the design of the chemical detector field simulator.

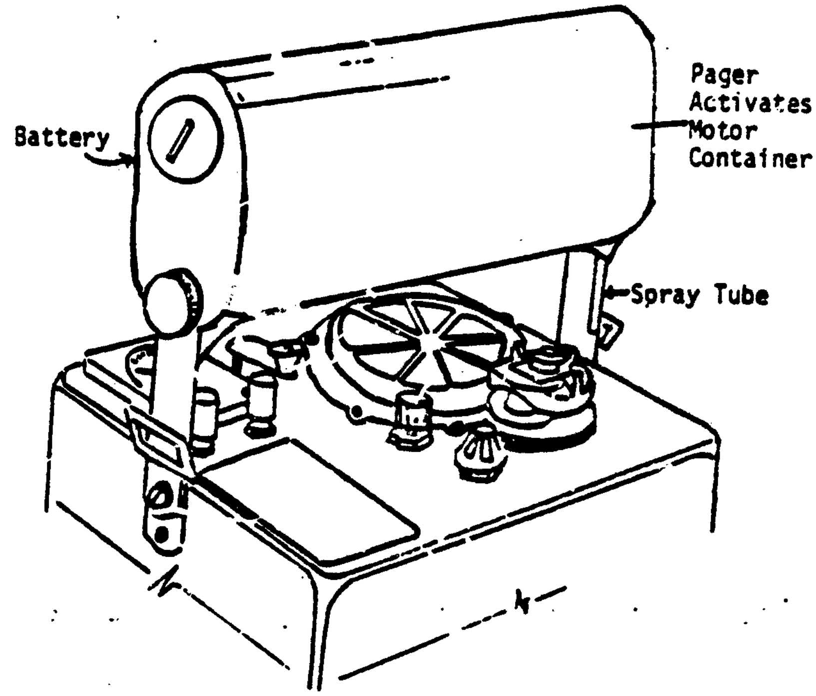


Figure 9. Simulator receiver/decoder/sprayer mounted in carrying handle.

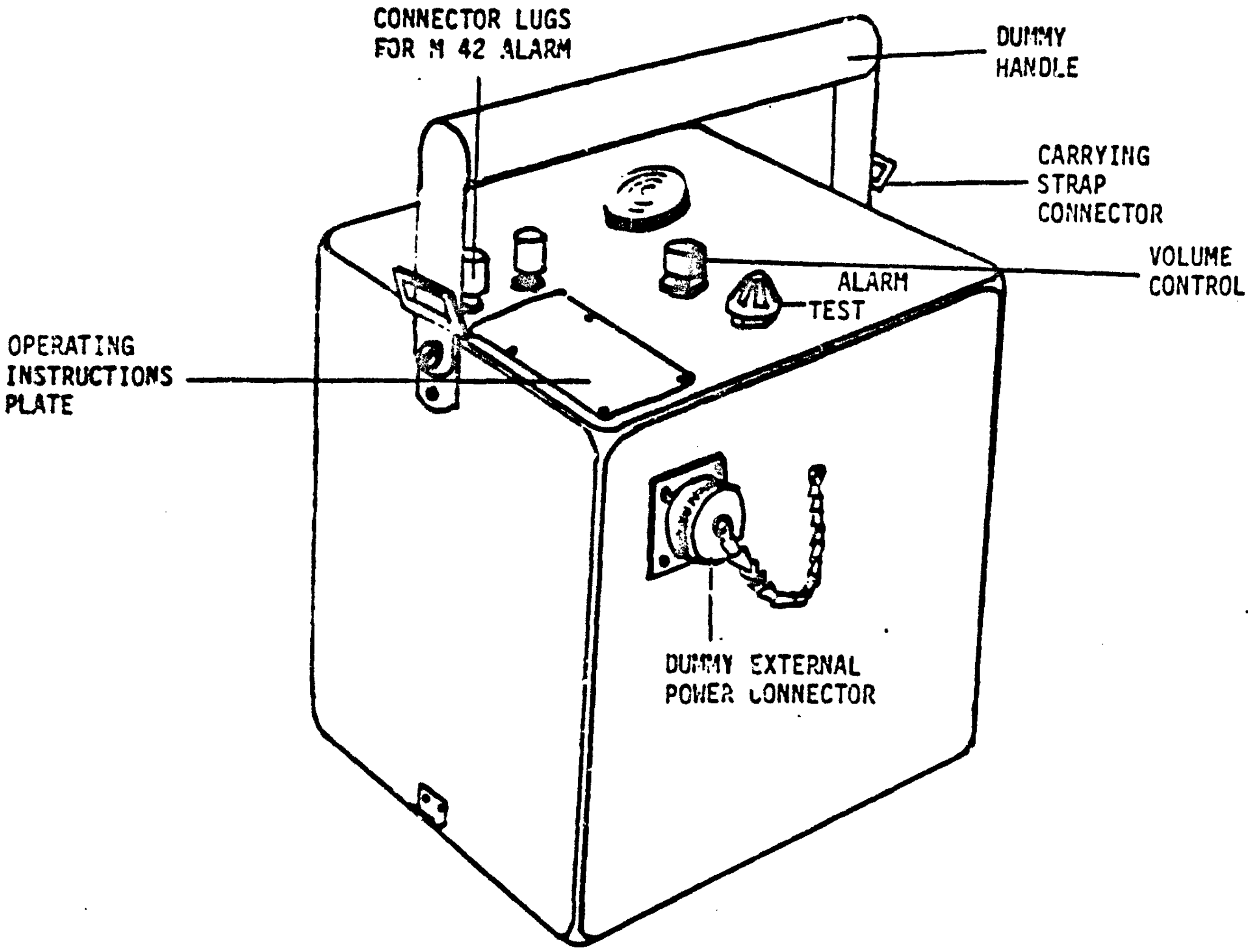


Figure 10. Alternate design for chemical detector simulator.

2.3.2.3 Design of the Radiacmeter Simulator

The IM 174 Radiacmeter is the principal means by which troops can measure the ambient nuclear radiation rate in the event of nuclear warfare. The radiacmeter simulator will provide readings which correspond to the calculated environment in the nuclear model in the CIS computer. The simulator should look like the actual meter and have a similar meter face.

Figure 11 shows the design alternatives decision tree used in this analysis. The pager selected as the receiver/decoder was the Motorola BPR 2000 Display Pager which provides a capability to receive a message containing ten digits. In order to utilize this information as received, circuitry was provided to convert the Motorola code to a more useable format. Figure 12 shows the arrangement of the simulator circuits.

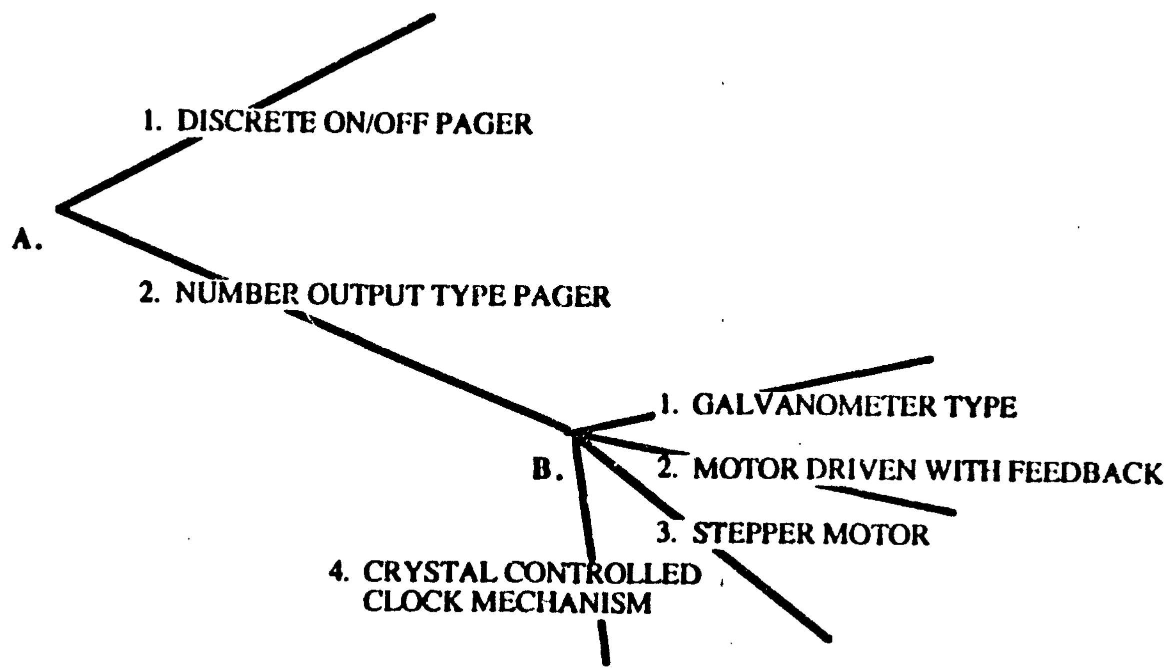
Various types of mechanisms were examined for the operation of the display. An adaptation of a commercial electronic mechanism was selected as providing the only acceptable battery requirement. It was also the simplest and most reliable.

There is adequate volume inside an actual radiacmeter case for all elements of the simulator, so that the overall appearance of the simulator will be very similar to the operational device. Tests of a prototype will determine the need for an external antenna. Figure 13 shows the external appearance of the simulator.

2.3.2.4 Design of the Dosimeter Simulator

The IM 93 Radiacmeter is a dosimeter which is carried by two members of each platoon sized units to provide a measure of the dose received by the platoon in the event of nuclear warfare. The design path for the dosimeter simulator is shown in Figure 14. Use of an actual dosimeter, which is an electroscope, with a reading artificially set by imposing an electric field was considered. This was rejected as unworkable due to non standard responses of the dosimeters.

The dosimeter is a relatively small device, so consideration was given to making the simulator the same size, but can be set by an external remotely controlled device. This was rejected in favor of a simpler, and inherently more reliable and lower cost integral simulator. Considerations of meter mechanizations and the type of receiver/decoder to be used were the same as for the radiacmeter described in the preceding section. Alternative means of lighting the meter to duplicate the see-through lighting of the actual device were also considered.



A. RECEIVER/DECODER TYPE   B. METER MOVEMENT

Figure 11. Path for the design of the radiacmeter simulator.

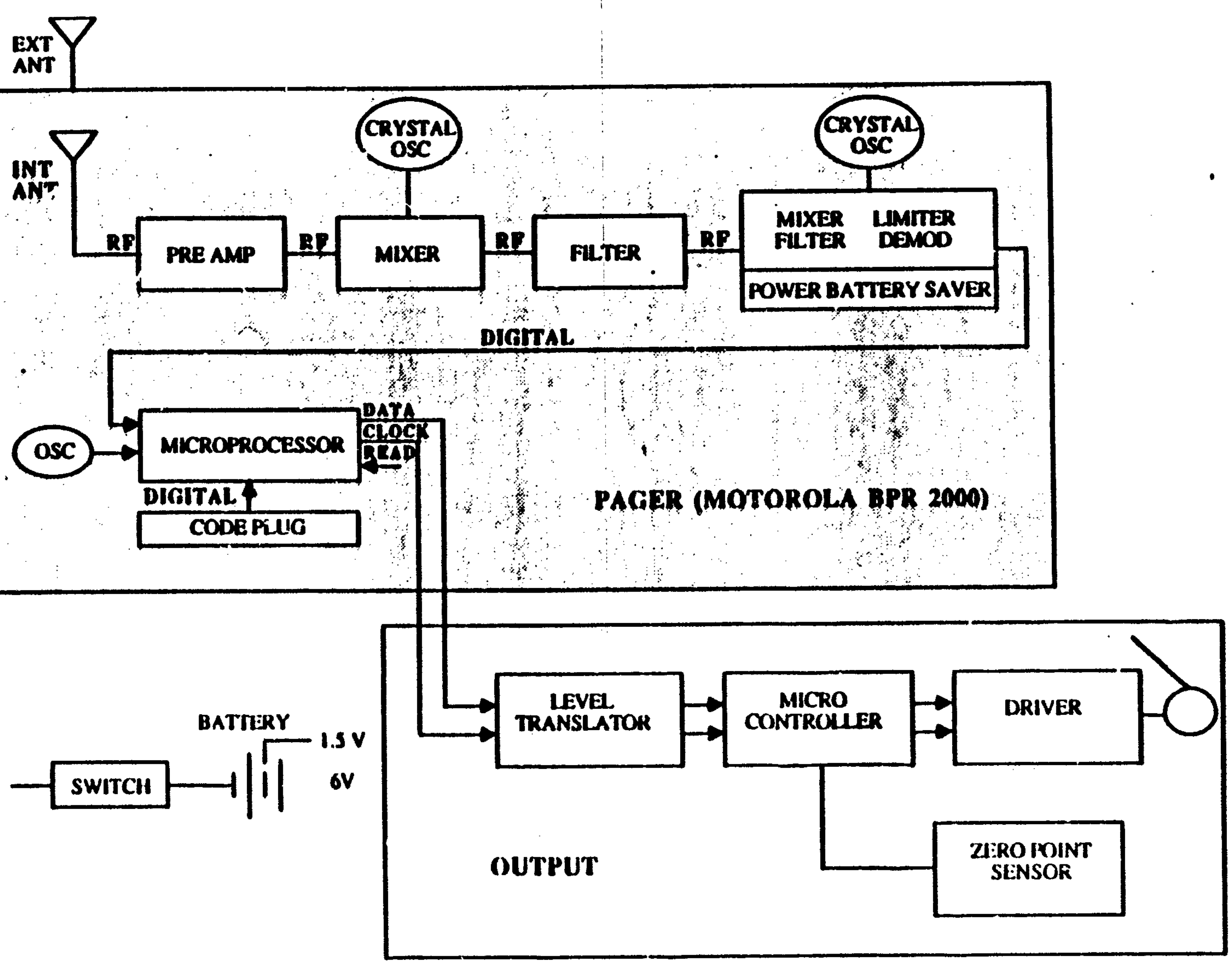


Figure 12. Radiacmeter dosimeter functional block diagram.

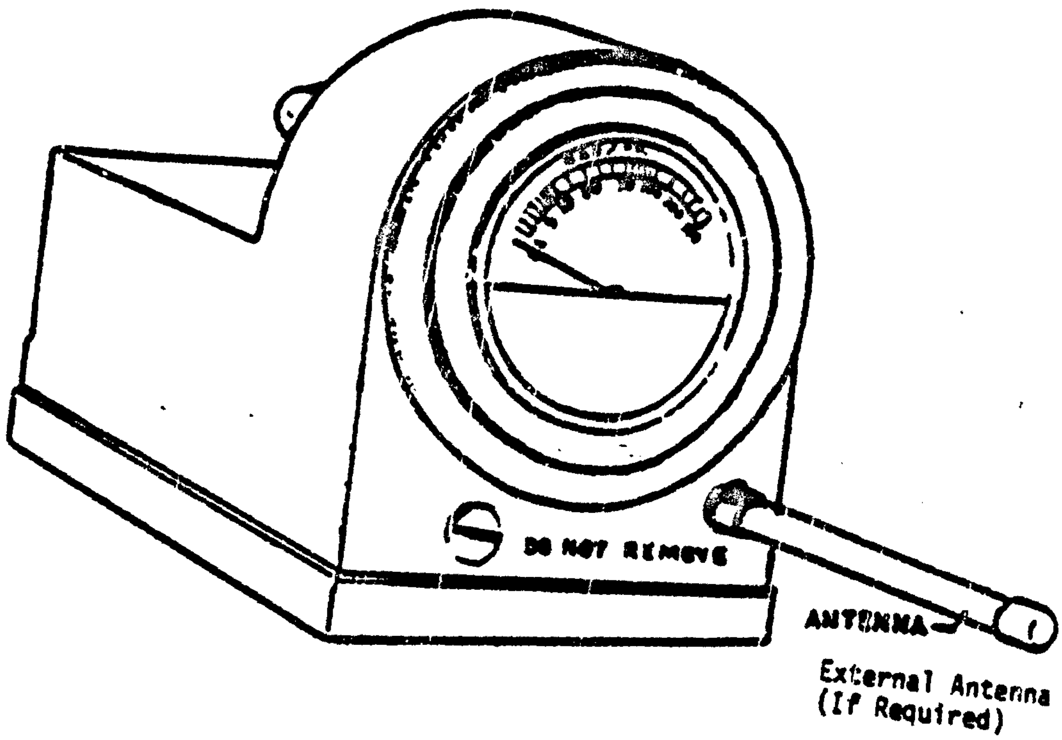


Figure 13. IM-174A/PD radiacmeter simulator.

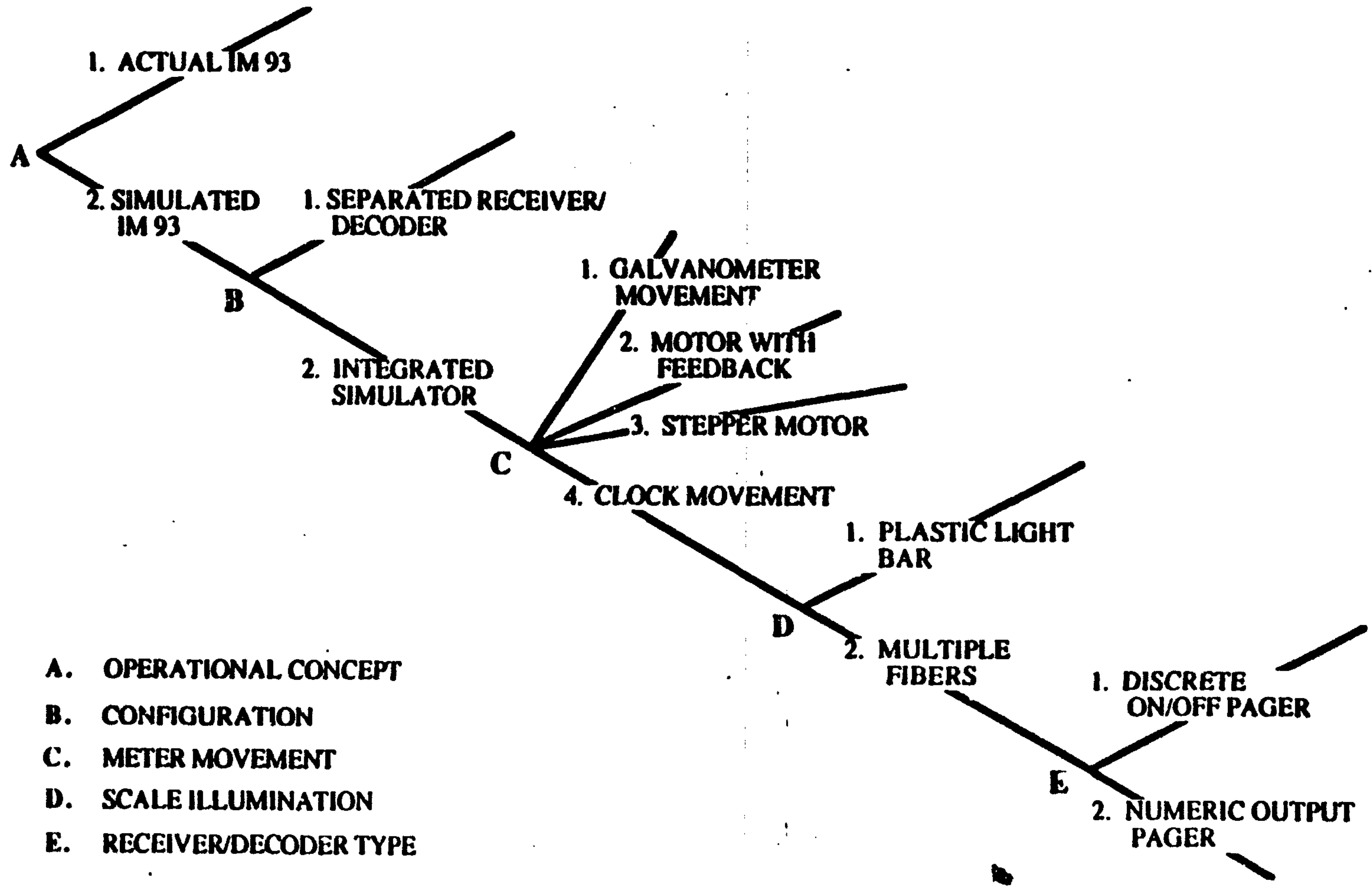


Figure 14. Path for the design of the dosimeter simulator.

In the selected design, the linear scale will be curved over a semicircle. The scale will be the same as the IM93. The simulator will be read in the same manner as the IM93. The cylindrical shape of the actual device will have a rectangular addition to house the receiver/decoder and meter mechanization. (See Figure 15)

2.4 SOW TASKS 13 THROUGH 18: COMMON INTEGRATED BATTLEFIELD MODEL

SOW Tasks 13-18 established a common training simulation model with integrated battlefield capability for the training of battalion and brigade command groups. This model has common algorithms and training capability to support a stand alone Command Post Exercise (CPX) environment and to support brigade level command and control training at the NTC. The tasks performed during this phase of the project resulted from coordination meetings that were held during Phase II between the Chief of the Battlefield Simulations Directorate at Ft. Leavenworth, the TRADOC System Manager of NTC at Ft. Monroe, and the COR at DNA Field Command. These meetings resulted in a determination that the model used to train battalion and brigade level personnel in the Army, regardless of whether it was at NTC or at home station, should be consistent in the functions being simulated, to include conventional, nuclear and chemical weapons. It was agreed that the model should be based upon ARTBASS, which is being developed as the battalion and brigade level training simulation for command groups. It was also agreed that a requirement exists for a training simulation to support division and corps level command and control training that includes IB capabilities.

The following tasks were then identified to be accomplished in Phase III of the project.

In SOW Task 13, the procedures, methods and potential problems of converting the prototype ARTBASS system for operation on equipment compatible with the NTC were studied and defined.

In SOW Task 14, approaches for accomplishing a division and corps level IB training simulation system, both within a short-term period (two years) and on a longer term basis (six years) were analyzed and described.

The actual conversion of the ARTBASS model for operation on NTC equipment was accomplished in SOW Task 15, and SOW Task 16 encompassed the adaptation of the man-machine interface aspects of ARTBASS for operation on NTC equipment.

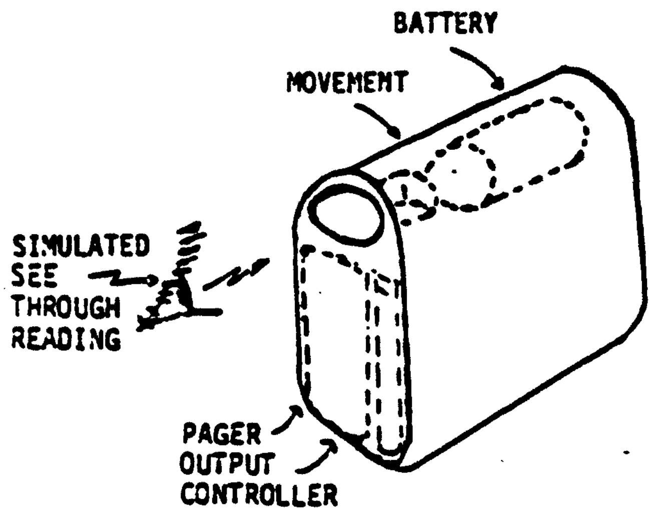


Figure 15. Dosimeter simulator.

In SOW Task 17, the nuclear and chemical models that were developed in SOW Task 10 were adapted and integrated for operation within ARTBASS.

Finally, in SOW Task 18 the final ARTBASS system, including the nuclear and chemical capabilities, was demonstrated on NTC-compatible equipment.

The following paragraphs provide additional detail on the approach and results of each of these tasks.

2.5 SOW TASK 13: COMMON INTEGRATED BATTLEFIELD SIMULATION FEASIBILITY ASSESSMENT

The purpose of this task was to study the environment, both hardware and software, of the prototype ARTBASS and the NTC system to identify potential difficulties in installing or coverting ARTBASS for operation on NTC equipment and to develop approaches to accomplishing that conversion. In addition, approaches for transferring new code installed on the VAX version of ARTBASS back to the native Perkin-Elmer equipment used on the prototype ARTBASS were developed. The study is documented in Appendix I.

The approach taken was to study and evaluate equipment commonality and differences, and the various aspects of use of FORTRAN programming language on the Perkin-Elmer and VAX computers. The assembly language aspects were studied as were the input and output characteristics of the two systems. The method of executing program modules and the command languages used for both systems were examined. Procedures for transfer of code between the two computer systems was evaluated and methods for accomplishing the man-machine interface through a front-end architecture were examined.

The feasibility study showed that conversion of the prototype ARTBASS system as it exists on the Perkin-Elmer equipment to NTC equipment is feasible and could be accomplished within the scope of Phase III of the project. The study was conducted before access was obtained to the actual ARTBASS code; however, the study identified several areas of potentially requiring large effort. These areas are identified, and the actual experience gained during work on converting ARTBASS (Tasks 16 and 17) is described below.

- The conversion of assembly language code was identifed as a potential problem area, but no such conversion was necessary since the ARTBASS prototype software, once it was obtained, did not contain any assembly language code.

- The use of program overlays in the Perkin-Elmer computer architecture was identified as a potential risk, but the prototype ARTBASS turned out not to contain any program module overlay requirements.

- Communication between tasks was identified as a high risk area. This effort was of medium difficulty, and was handled through the design and writing of a VAX version of the task communication module that existed in the ARTBASS prototype.

- Code unification was identified as a relatively difficult task. In the final analysis, this turned out to cause major problems in converting the software from the Perkin-Elmer to the VAX computer, but the methods and procedures for resolving this problem in the future were identified and documented.

- Interface of the ARTBASS model to the front-end software (i.e., the man-machine interface software) was identified as a high risk area; however, it was simply accomplished through use of a single VAX computer rather than a multi-CPU Perkin-Elmer system and using the converted task communication capability described earlier.

- Development of the front-end architecture, that is, the integration of the NTC display and input devices to the ARTBASS model, was not difficult from a conceptual standpoint but did consume much effort during the project. In particular, the adapting of alphanumeric alerts and reports to the Digital Equipment Corporation terminal was a major undertaking.

The feasibility study was performed at a time before the prototype ARTBASS system was available for use during the study; therefore, several items were identified as potential problems that turned out to be of little consequence, as indicated above. Other areas that were not identified in the study, however, turned out to be of significant difficulty and caused considerable work. The major example of the latter situation is the use of the symbol dictionary capability within the prototype ARTBASS system. This capability did not exist on the VAX and had to be implemented and integrated on the VAX system in order to provide the necessary compatibility with the prototype ARTBASS software.

2.6 SOW TASK 14: REQUIREMENTS ANALYSIS FOR DIVISION/CORPS INTEGRATED BATTLEFIED TRAINING SIMULATION

The purpose of this task was to serve as one portion of a total study being performed by the Combined Arms Operations Research Agency (CAORA) at Ft. Leavenworth to establish the best technical approach for developing both a short-term (two years) and a long-term (six years) development of an integrated battlefield command and control training simulation for division and corps command groups.

The first step taken in this study was to identify and analyze the training audience that would be served by the simulation system, and to identify the general requirements of the system. To do this, organizational and operational concepts of the corps and divisions were examined, key staff elements and agencies that interact with division and corps command groups were identified. Information flow analysis was conducted to identify the types of stimulus and response that a simulation system would have to provide to allow realistic training of these command groups. The data produced by these ativities provided a baseline against which potential approaches for development of the division/corps training simulation system could be evaluated.

The next phase of the study dealt with review and evaluation of seven candidate simulations and models which potentially could be used as baselines for implementation of the desired training simulation system. The models evaluated were as directed by CAORA and purposely did not include certain models that they were studying separately. The models studied within this project were ARTBASS, FOURCE, (Command Control, Communications, and Combat Effectiveness model), JANUS, MTM (McClintic Theater Model), STAR (Simulation of Tactical Alternative Responses), TACSIM, and VECTOR-3 Model. Each of these models were described in terms of their structure, the functions provided, and the system on which they operated. A comparative evaluation of the key attributes of the models was prepared.

Of the systems included in the study, ARTBASS was determined to be the best choice to serve as a baseline for developement of the desired simulation system. The actions necessary to adapt ARTBASS to operate at the division level were identified and enhancements were described that would be necessary to provide a sufficient training environment for varied division level staff officers. Also, a long-term approach was defined to expand the short-term solution and to allow more varied training environments for both corps and division level training.

Finally, development approaches were analyzed and described for both the short-term and the long term fra.es. The report resulting from this task is contained in Appendix J.

2.7 SOW TASKS 15, 16, AND 17: ARTBASS CONVERSION AND NUCLEAR/CHEMICAL INTEGRATION

There was significant commonality of effort and documentation for SOW Tasks 15, 16 and 17, therefore, these three tasks are described together in this paragraph.

Based upon the results of the feasibility study performed in SOW Task 13 and the analysis of the prototype ARTBASS software after it was received, the approach for converting the ARTBASS model to the VAX computer was finalized. The ARTBASS model was not modified at all, however, certain software features were modified to accomodate the different equipment configuration. Principally, the changes dealt with input and output routines for handling data bases, and changes to the methods for handling ASCII to binary code conversions and the handling of bit and byte data. Also, symbol dictionary software and data bases had to be converted for operation on the VAX and installed on the VAX computer.

Together with the conversion of the model, the interface design and control (IDC) aspects of the system were designed and implemented. The capability of manipultating digital terrain maps and use of a Master Menu through manipulation of a grahics tablet were adapted from similar capabilities used in the NTC software system. Other functions, to include interactive menus, graphic symbology, and alphanumeric alerts and status reports, were converted and adapted from the sotware used in ARTBASS. The IDC software was partially tested independently and then completely tested in an integrated fashion with operation of the ARTBASS model.

Appendix K contains details concerning the conversion of ARTBASS software and integration of IDC software that eventually provided operation of ARTBASS on the NTC equipment. Included are descriptions of the model and IDC designs, and descriptions of software conversions that were performed on a mass basis using specially developed software tools. There is also a section on software changes that were required to be made that are not compatible with the Perkin-Elmer equipment, and, therefore, cannot be transferred back to the Perkin-Elmer equipment. These routines principally involve equipment-dependent input and output routines. Another section of Appendix K describes software changes made that are compatible with the Perkin-Elmer computer. These changes mainly involve the

manipulation of bits and bytes of data within the machine and are necessary for correct operation on both the VAX and the Perkin-Elmer computers. Several software corrections wee necessary to provide correct operation of ARTBASS on the VAX computer, and are described in the appendix. These corrections fall into three areas. The first area deals with the fact that the FORTRAN compiler on the Perkin-Elmer system was operated without providing checks on array sizes and similar data base manipulation capabilites within the FORTRAN code. As a result, certain of the indexes and subscripts were found to be out of range of the data being accessed. Also, there were some logic errors discovered. And, thirdly, several errors were discovered in the content of the scenario data base used in ARTBASS.

The final section of the Appendix K discusses the procedures and techniques for transferring ARTBASS source code from the VAX computer back to the Perkin-Elmer computer system. This would allow software used as part of training concept development activities on the VAX system to be transferred and installed on an operational ARTBASS system using the Perkin-Elmer equipment.

After the basic prototype ARTBASS software was operational on the NTC equipment, the nuclear and chemical models developed in SOW Task 10 were integrated and adapted to ARTBASS. Certain aspects of the models differed from the operation for the NTC. These changes deal essentially in the methods for assigning and awarding casualties, determining degrees of unit degradation and contamination, and in determining the damage caused to the terrain resulting from nuclear events. To allow proper control and role playing of nuclear and chemical events with ARTBASS, the model and the existing ARTBASS man-machine interface were analysed and a requirements design specification for the addition of nuclear and chemical capability to ARTBASS was developed. This specification is included in Appendix M. It describes the types of simulation being performed as a result of nuclear and chemical events, the me us used to control operation of these events, the symbology used to display the effects, and the alphanumeric alerts and status reports that reflect the key events happening in the battlefield.

2.8 SOW TASK 18: DEMONSTRATION/EVALUATION

Demonstrations accompanied by briefings were developed which show the various capabilities resulting from SOW Tasks 13 through 17. The briefing presents the system architecture, conversion methods, and source code transfer procedures contained in Appendix K. The demonstration consists of exercising ARTBASS on NTC compatible equipment using a

scenario that includes opposing forces employing conventional, nuclear, and chemical weapons, followed by free-play, interactive use of ARTBASS. (Presentation of the briefings and demonstations were done 9 January 1985 through 18 January 1985).

SECTION 3

CONCLUSIONS

3.1 IB TRAINING SOFTWARE SYSTEM

Nuclear and chemical models have been developed which satisfy the NTC training requirements. The software was developed with embedded calls to and from the NTC CIS software. There appear to be no significant difficulties associated with installing the software on the CIS computer nor in the operational aspects of utilizing the system.

3.2 IB COMMAND AND CONTROL CAPABILITY DEMONSTRATION

Based upon the results of the IB Command and Control Capability Demonstration, it appears feasible to provide a means to monitor, control and provide training feedback for a combined (concurrent) CPX and FTX; thus, exercising the IB planning and execution activities of BDE/BN commanders and their staffs. The processing and displaying of combined real and notional activities was demonstrated, with no major problems encountered.

3.3 NUCLEAR AND CHEMICAL EFFECTS SIMULATORS

The following conclusions were derived from research provided in this task:

- NTC IB Training effectiveness could be significantly increased by the incorporation of selected field simulators in the NTC system concept.
- Resources required by devices which would be provided to each player or individual make these devices less cost-effective then those provided only to specialists.
- There are no significant interface problems associated with the use of field simulators which cannot be resolved.
- The current technical risk and cost associated with the masking/timer casualty indicator makes its training cost-effectiveness questionable at this time.

- Preliminary designs of the three selected field simulators (chemical detectors, radiacmeters, and dosimeters) and the common control system indicate that these field simulators are both feasible and cost-effective.

- Commercial off-the-shelf pagers are a feasible approach to a common control system with a demonstrated capability to cover the entire Fort Irwin operational area of interest.

- The initial design of the chemical detector appears to have considerable design risk. An alternative design was found to be acceptable.

- All field simulator designs use, for the most part, readily available off-the-shelf components.

3.4 COMMON IB TRAINING MODEL DEMONSTRATION

Conclusions of the research performed on SOW Task 13 through 18 are as follows:

- Installation of ARTBASS on NTC-compatible equipment was sucessfully achieved and the resulting system is very adaptable to enhancement and experimentation with capability to export enhancements back to the native ARTBASS computer system (Perkin-Elmer).

- ARTBASS is a viable baseline for development of a division/corps integrated battlefield training simulation.

- Incorporation of NTC compatible nuclear and chemical models into ARTBASS provides an effective common command and control integrated battlefield training environment.

SECTION 4

RECOMMENDATIONS

4.1 IB TRAINING SOFTWARE SYSTEM

It is recommended that the IB nuclear and chemical environments and effects software be modified to include changes which have been identified which were beyond the scope of the DNA sponsored research program. It is recommended that the modified software be installed on the NTC CIS computer, to include user documentation and operational training. This recommended work should be carried forward under TRADOC/NTC funding.

4.2 IB COMMAND AND CONTROL CAPABILITY DEMONSTRATION

TRADOC/NTC should review the results of the successful IB C3I capabilities demonstration in light of their long term command staff training needs at the NTC and assess the impact of such a concept on NTC operational requirements (i.e. staffing). An evolutionary phased approach to acquiring an IB C3I BDE/BN command staff training capability should be investigated.

4.3 NUCLEAR AND CHEMICAL EFFECTS SIMULATORS

- It is recommended that field simulators having high cost-effectiveness (i.e., chemical detector, radiacmeter, and dosimeter) be constructed and demonstrated in brassboard form, based on the designs developed in this research.

- It is recommended that additional research be done to determine if there is a harmless chemical that will reliably activate the M43 chemical detector.

- It is recommended that software to control the field simulators be developed and demonstrated.

- It is recommended that the design risk for the common control system be further reduced by testing of the transmitters and decoders/receivers in a complete NTC engagement simulation RF environment.

- It is recommended that a survey be made of the number of M43 detectors which are actually issued to battalions, to determine if a system of utilizing actual detectors in battalion unit training is practicable.

This recommended research work should be carried forward by DNA to the point where the key field simulators and their associated software have been demonstrated in a prototype/brassboard form.

4.4 COMMON INTEGRATED BATTLEFIELD TRAINING SIMULATION

The following actions are recommended to exploit the work performed under the current project and provide a greatly enhanced integrated battlefield training simulation for the Army.

- Analyze functions that would round out the training environment of battalion and brigade command staffs and, based on that analysis, perform development to support concept evaluation of enhancements to ARTBASS in areas such as administration, medical decontamination, use of rotary-wing aircraft for evacuation, and the effect of nuclear and chemical events on performance of rotary-wing units.
- Perform detailed requirements definition of those items necessary to raise ARTBASS to a division level model, and the enhanced functions necessary to support division level IB command and control training.
- Based upon detailed requirements definition, implement division level IB training simulation capability based on ARTBASS.

These efforts should be carried forward by U.S. Army funding using the results of the DNA sponsored research performed under this contract.

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